UNIVERSITI PUTRA MALAYSIA

PERSISTENCE OF CYPERMETHRIN, DELTAMETHRIN AND ENDOSULFAN IN AN OIL PALM AGROECOSYSTEM

MA CHOON KWONG

FP 2002 14

PERSISTENCE OF CYPERMETHRIN, DELTAMETHRIN AND ENDOSULFAN IN AN OIL PALM AGROECOSYSTEM

By

MA CHOON KWONG

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

March 2002

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

PERSISTENCE OF CYPERMETHRIN, DELTAMETHRIN AND ENDOSULFAN IN AN OIL PALM AGROECOSYSTEM

By

MA CHOON KWONG

March 2002

Chairman: Associate Professor Dzolkhifli Omar, Ph.D.

Faculty: Agriculture

A study on the persistence of cypermethrin, deltamethrin and endosulfan in an oil palm agroecosystem was conducted at a Sime Darby estate in Sungai Buloh, Selangor. Three experimental plots in the estate were sprayed with cypermethrin, deltamethrin and endosulfan, respectively. The insecticides were sprayed using a motorized mist blower at the manufacturer's recommended dosage and double the recommended dosage. The application was conducted in triplicate plots. Composite soil samples were collected from each replicate plot at 0-10, 10-20, 20-30, 30-40 and 40-50 cm depth. Palm fronds were randomly harvested from the plots and water samples were collected from the adjacent streams and drains along the plots. The insecticide residues in soil, water and palm leaves were monitored at 1, 3, 7, 14, 30, 60 and 90 days after treatment.

Analytical methods for endosulfan, cypermethrin and deltamethrin residues were evaluated and good recoveries were observed for the matrices examined. A gas chromatograph equipped with an electron capture detector was used to quantify the pesticide concentrations in the extracts.

Endosulfan was more persistent than deltamethrin and cypermethrin in the soil, with half-lives of 38, 5 and 2 days, respectively. The corresponding values for palm leaf were 9, 4 and 6 days. None of the insecticides studied was found leached beyond 10 cm of the soil profile. Residue concentrations of the insecticides in soil and palm leaf were in the range of 0.001 to 0.19 mg/kg and 0.001 to 2.40 mg/kg respectively. Surface runoff of the insecticides however, was not evident in the agroecosystem as no residues were detected in the surface waters from adjacent drains and streams.

The usefulness of two computer models, VARLEACH and PERSIST in predicting the fate of the insecticides in oil palm agroecosystem was assessed by comparing the field data with predicted data. Predictions with VARLEACH gave better agreement with observed insecticides residues than PERSIST. VARLEACH predicted cypermethrin, deltamethrin and endosulfan did not leach beyond 10 cm of the soil profile, which was in agreement with the field observation.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KEKEKALAN CYPERMETHRIN, DELTAMETHRIN DAN ENDOSULFAN DALAM AGROEKOSISTEM SEBUAH LADANG KELAPA SAWIT

Oleh

MA CHOON KWONG

Mac 2002

Pengerusi: **Profesor Madya Dzolkhifli Omar, Ph.D.**

Fakulti: **Pertanian**

Satu kajian mengenai kekekalan cypermethrin, deltamethrin dan endosulfan dalam agroekosistem kelapa sawit telah dijalankan di sebuah ladang Sime Darby di Sungai Buloh, Selangor. Tiga plot kajian yang dipilih masing-masing disemburi dengan cypermethrin, deltamethrin dan endosulfan. Semburan adalah mengikuti dos cadangan pengeluar dan dua kali ganda daripada dos cadangan. Semua penyemburan dilakukan dalam tiga replikasi termasuk plot kawalan. Sampel tanah komposit diambil dari setiap plot pada kedalaman tanah 0-10, 10-20, 20-30, 30-40 dan 40-50 cm. Daun kelapa sawit disampel dari setiap plot dan sampel air diambil daripada longkang dan sungai yang berhampiran dengan plot kajian. Persampelan tanah, daun dan air dibuat pada 1, 3, 7, 14, 30, 60 dan 90 hari selepas applikasi racun makhluk perosak.

Keberkesanan kaedah analisis telah diuji sebelum pengekstrakan sisa baki racun dijalankan ke atas sampel. Gas kromatografi yang dilengkapi dengan ECD (*electron capture detector*) telah digunakan untuk penentuan kuantiti racun.

Keputusan analisis menunjukkan endosulfan memiliki separuh hayat yang lebih panjang daripada cypermethrin dan deltamethrin di tanah dengan separuh hayat 38, 5 dan 2 hari masing-masing. Separuh hayat untuk ketiga-tiga racun perosak di dalam daun ialah 9, 4 dan 6 hari masing-masing. Kepekatan sisa racun di antara 0.001-0.19 mg/kg telah dijumpai di dalam tanah, manakala kepekatan di dalam daun ialah 0.001-2.40 mg/kg. Tiada sebarang sisa baki racun dikesan di dalam tanah dari kedalaman lebih daripada 10 cm. Sisa baki racun juga tidak dapat dikesan di air permukaan longkang dan sungai yang berdekatan.

Keberkesanan VARLEACH dan PERSIST dalam meramalkan kekekalan racun makhluk perosak pada agroekosistem ladand kelapa sawit telah diuji dengan membandingkan keputusan ramalan dengan keputusan kajian. VARLEACH dapat meramalkan jumlah sisa baki racun dengan lebih tepat jika dibandingkan dengan PERSIST. VARLEACH berjaya meramalkan pergerakan racun tidak melebihi 10 cm dari permukaan tanah sejajar dengan keputusan kajian.

ACKNOWLEDGEMENTS

I wish to express my gratitude to my supervisors Dr. Dzolkhifli Omar, Dr. Cheah Uan Boh and Dr. Ainie Haji Kuntom for their time, patience and guidance in ensuring the successful completion of this study. I am also grateful to their kindness for giving me the opportunity to attend courses, seminars and conferences that have benefited me a lot.

I would like to thank Malaysia Palm Oil Board (MPOB) for financing the project and granting me the scholarship. Deepest gratitude to the Director General of Malaysia Agricultural Research and Development Institute (MARDI) for providing the laboratory facilities. Special thanks to the technical staff from MARDI, in particular Mr. Lim Teck Poi for his help with gas chromatograph analysis, Puan Jamiah, Puan Siti, Puan Rosmawati and Mr. Lim Kim Peng for their guidance and technical assistance in laboratory analysis.

I would also like to thank Mr. Chung Gait Fee and Mr. Balasubramaniam Ramalingam from Ebor Research, Sime Darby. The project would not be successful without their technical advices and valuable assistance on field aspects. Appreciation also goes to Sime Darby Management for their generosity in allowing the experiment to be conducted in their plantation.

To my valuable friends Ngan Chai Keong, Chia Joo San, Lim Ah Hong, Poan Choy Ling, Suttipong Pruangka and Mongkon Ta_oun. Their help, opinions, support and comments are deeply appreciated.

Finally, I wish to express my gratitude to my parents for their understanding and encouragement all these years.

I certify that an Examination Committee met on 7th March, 2002 to conduct the final examination of Ma Choon Kwong on his Master of Science thesis entitled "Persistence of Cypermethrin, Deltamethrin and Endosulfan in an Oil Palm Agroecosystem" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

RAJAN AMARTALINGAM, Ph.D.
Associate Professor,
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

DZOLKHIFLI OMAR, Ph.D.
Associate Professor,
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

CHEAH UAN BOH, Ph.D.
Research Officer,
Centre for Strategy, Environment and Natural Resources
Malaysia Agricultural Research and Development Institute
(Member)

AINIE HAJI KUNTOM, Ph.D.
Head of Unit,
Analytical and Quality Development Unit
Malaysia Palm Oil Board
(Member)

SHAMSHER MOHAMAD RAMADILI, Ph.D.
Professor/Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 16 APR 2002

This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfillment of the requirement for the degree of Master of Science.

AINI IDERIS, Ph.D.
Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date : 13 JUN 2002

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

MA CHOON KWONG

Date : 16 April 2002

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

CHEMICAL NAMES OF PESTICIDES MENTIONED IN THE TEXT

Common name	Chemical name
Acephate	O, S-dimethyl acetylphosphoramidothioate
Chlorpyrifos	O, O-diethyl O-(3, 5, 6-trichloro-2-pyridyl) phosphorothioate
Cyfluthrin	Cyano(4-fluoro-3-phenoxy-phenyl)methyl3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate
Cypermethrin	(RS)-α-Cyano-3-phenoxybenzyl(1RS)-cis,trans-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate
Deltamethrin	(S)-α-Cyano-3-phenoxybenzyl(1R)-cis-3-(2,2-dibromovinyl)-2,2 dimethylcyclopropanecarboxylate
Dieldrin	3,4,5,6,9,9-hexachloro-1a-alpha, 2-beta, 2a-alpha, 3-beta, 6-beta, 6a-alpha, 7-beta, 7a-alpha-octahydro-2, 7:3, 6-dimethanonaphth [2,3-6] oxirene
Diuron	N-(3,4-dichlorophenyl)-N,N-dimethyl urea
Endosulfan	Thiodan, 6,7,8,9,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin 3-oxide
Glyphosate	N-(phosphonomethyl) glycine
Methyl-metsulfuron	Methyl 2-[3-(4-methoxy-6-methyl-1,3,5-triazin-2-yl)ureidosulphonyl]benzoate
Permethrin	3-phenoxybenzyl(1RS)-cis,trans-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate
2,4-D	(2,4 dichlorophenoxy) acetic acid

LIST OF ABBREVIATIONS

Abbreviation	Interpretation
a.i	Active ingredient
Endo	Endosulfan
DAT	Days after treatment
GC	Gas Chromatograph

CHAPTER 1

INTRODUCTION

Malaysia, assisted by well-developed and financed research and development facilities, has emerged as the largest producer of palm oil in the world. The production of palm oil and related products has contributed to the country's wealth and economy. In 1998, during the economic recession, oil palm industry became the main pillar to uphold the country's economy. In the year 2000, Malaysia sold 10.38 million tones of crude and processed palm oil providing about RM12.47 billion of income to the country (MPOB, 2001). Besides the development and quality control of the palm oil products, pest and disease management is essential to ensure the continued growth and expansion of the industry.

The hot and humid climate of the country and narrow genetic base of oil palm have resulted in the susceptibility of oil palm to pests and diseases (Rajanaidu *et al.*, 1982; Khoo, 1986). The major insects that attack oil palm in Malaysia are bagworms, neetle caterpillars and rhinoceros beetle (Wood, 1968). The common species of bagworms attacking oil palm are *Metisa plana* Walker, *Pteroma pendula* Joannis and *Mahasena corbetti* Tams (Chung, 1989). Wood *et al.* (1973) reported that a single outbreak of the pest could cause 30-40% loss of crops over a period of two years. Although integrated pest management strategies are being promoted and implemented, pesticides remain as essential tools in the pest management of oil palm plantation.

Commonly used insecticides in the oil palm plantation are cypermethrin, deltamethrin, acephane, chlorpyrifos and carbofuran. Besides insecticides, herbicides and rodenticides are being used to control weeds and rodents respectively. In summary, the consistent yield of palm oil would not be achieved without the use of pesticides.

In Malaysia, the use of pesticides in rice, tobacco and vegetable agroecosystems has been reported to result in the contamination of soils and water sources (Enoma *et al.*, 1999a; Cheah *et al.*, 1994). Endosulfan was found as a predominant contaminant in rice and tobacco agroecosystems (Cheah *et al.*, 1994). Cypermethrin and deltamethrin is of popular use in oil palm plantations due to their effectiveness to control pest outbreak (Chung and Narenda, 1996). The increased use of pesticides has resulted in a growing concern over the risks of their residues in the environment. There is however, lack of information on the effects of sustained use of pesticides on oil palm agroenvironment. Data on the rate of degradation are vital for risk assessment of environmental safety as they show the amount of residue remaining in the environmental compartments. In addition, pesticide residue data are a pre-requisite for establishing maximum residue limits, in which these limits are important for facilitating the export of palm oil and the protection of human health.

The use of computer modeling is important as a supplement to the field study. Modeling permits prediction and extrapolation of residue data in order to save cost and time. The popular calf models, VARLEACH and PERSIST have shown their usefulness in the prediction of pesticide residues and leaching. Before the model can be recommended for use in the risk assessment of pesticides, it is necessary to test the model under local soil and weather conditions.

The objectives of this study were to determine the persistency and leaching of cypermethrin, deltamethrin and endosulfan in an oil palm agroecosystem by conducting a field residue trial and to assess the usefulness of two simulation models, VARLEACH and PERSIST in predicting the persistency of the insecticides in the oil palm agroecosystem.

CHAPTER 2

LITERATURE REVIEW

2.1 Pesticides in the Environment

Pesticides that are applied on the crop can move to other parts of the environment where they may pose adverse effects to non-target organisms including man. The low efficiency of pesticide spraying methods has further aggravated the transportation of pesticides to the environment and non-target organisms (Omar, 2000). Numerous cases of pesticide residues and their effects on non-target organisms have been reported (William *et al*., 1972). Contamination of various pesticides in food products such as vegetables, fruits, cereals and milk was evident (MAFF, 1996). Cheah *et al*. (1994) demonstrated the use of pesticides in rice, tobacco and vegetable agroecosystems has resulted in the contamination of soil and water sources.

The rate of degradation in soil is one of the most important criteria in determining the behavior of a pesticide in the environment (Goring and Hamaker, 1975). Data on the rate of degradation are vital for risk assessment of environmental health as they permit prediction of the amount of pesticide residue remaining in the environmental compartment (Cheah and Lum, 1998). Field studies are good sources of information on the degradation rates of pesticide. However, variability of climate, pesticide application and sampling exercise are beyond the control of the experimental set up (Laskowski *et* *al*., 1983). The alternative approaches are laboratory studies and modeling (Smith and Walker, 1977; Walker, 1978).

2.2 Factors Affecting Rates of Degradation/Dissipation

Pesticides can be lost from soil through volatilization, photochemical degradation, leaching and uptake by plants (Walker, 1987). The inherent degradability of molecular structure of a pesticide (Briggs, 1976), the condition of environment and properties of soil (Edwards, 1972) influence the rate of degradation. Adolphi (1965) reported that the persistence of a pesticide in the soil was influenced by the type of soil. He found that dimethoate persisted for 20 days in a sandy soil but for only 15 days in a clay soil. Chapman *et al*. (1981) demonstrated higher persistency of cypermethrin in soil with high organic matter and high clay content. Adsorption increased as clay content increased, thus resulting in reduced availability of the pesticide to the degradation.

Soils having coarse and sandy textures are generally more permeable than loamy or clayey soils. Kathpal *et al*. (1997) noted that high permeability of sandy loam of cotton soil enhanced the downward movement of a pesticide. Low solubility of a pesticide in water however, resulted in negligible downward movement with irrigation and rain.

Apart from leaching, pesticides can contaminate surface water through runoff. Runoff is the physical transport of pollutants over the ground surface by rainwater, snowmelt or irrigation water that do not penetrate the soil. The movement of pesticide by runoff is influenced by a variety of factors (Hill, 1989) as follows:

a) severity and period of rainfall
b) length of period between application and rainfall
c) soil characteristics including infiltration, water content prior to rainfall, cultivation, surface crusting, etc.
d) topography of land
e) pesticide physicochemical properties, e.g. water solubility, volatility
f) agronomic methods, such as pesticide formulation and placement

Racke and Coats (1987), Hendy and Richardson (1988) and Deo (1994) reported that microorganisms in the soils play an important role in the degradation of pesticides. According to Alexander (1967), pesticides that have molecular structures similar to substrates needed by the soil microorganisms are decomposed for food. Significant differences in the rate of degradations of 2-4-D in sterilized and non-sterilized soil had been observed by Cheah and Lum (1998). They noted that the degradation rate of the pesticide was critically affected by microbial degradation. Frehse and Anderson (1983) described the three major factors affecting the rate of microbial degradation as chemical availability, the amount of microbial biomass and its relative activity.

Besides the physicochemical properties of pesticides and environmental factors, dissipation of pesticides is also influenced by variables such as fertilizer application,